Radiological Health Data and Reports

VOLUME 12, NUMBER 10

OCTOBER 1971

(Pages 495-540)

ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	ji'ga
10^{6}	mega	M	měg'a
10^{3}	kilo	k	kil'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mil'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	nan'o
10^{-12}	pico	p	pe'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	at'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km²	square kilometer(s)	
kVp	kilovolt peak	
m³	cubic meter(s)	
mA	milliampere(s)	
mCi/mi²	millicuries per square mile	0.386 nCi/m² (mCi/km²)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi²	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m²	nanocuries per square meter	2.59 mCi/mi²
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 12, Number 10, October 1971

Radiological Health Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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RADIOLOGICAL HEALTH DATA AND REPORTS

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ENVIRONMENTAL PROTECTION AGENCY

William D. Ruckelshaus, Administrator

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Reports

A Joint X-ray Radiation Survey in Puerto Rico, 1968

Michael Gileadi[1]

The objectives, scope, and methods used in the 1968 Joint Radiation Survey Project, sponsored jointly by the Puerto Rico Nuclear Center and by the Department of Health of the Commonwealth of Puerto Rico, are described. The most significant results concerning the western and southern regions of the island are presented. Most of the three quantifiers (mean gonadal dose, per capita per annum gonadal dose, and genetically significant dose) were smaller in the southern region than those in the western region.

Cognizant of the potential health hazards associated with x-ray exposure, a survey was initiated in Puerto Rico in 1968, to find methods to minimize diagnostic x-ray exposures without interfering with the diagnostic information required. The survey was sponsored jointly by the Department of Health of the Commonwealth of Puerto Rico and the Puerto Rico Nuclear Center.

The primary objective of the project was to evaluate the dose to the patient due to unintentional irradiation of the gonads during abdominal and thoracic diagnostic x-ray examinations. Based on the results of the study, recommendations, compatible with the diagnostic information required, may be made to the owner or operator of the machine to reduce the hazards to a minimum.

Among the several indices designed to characterize the dose to the patient, the following were used in this survey:

1. Mean gonadal dose per diagnostic x-ray examination considered,
2. Per capita per annum gonadal dose due to the diagnostic x-ray examination considered, and
3. Genetically significant dose due to diagnostic x-ray examination considered.

Results of previous research (*1–4*) in this field established the fact that the largest contribution to the genetically significant dose (actually 80 to 90 percent of the total dose to the gonads) is due to a relatively small group of abdominal and pelvic examinations. In accordance with this observation, the following diagnostic x-ray procedures were included in the Puerto Rico survey:

1. abdomen,
2. gallbladder (cholecystography),
3. upper gastrointestinal series,
4. lower gastrointestinal tract (barium enema),
5. lumbar spine,
6. pelvic,
7. hip joint,
8. intravenous pyelography (I.V.P.) or retrograde pyelography, and
9. pelvimetry.

The objective of characterizing the radiation hazards by the three indices enumerated dictated the following scope and order of work in our survey:

1. Careful collection and extensive statistical analysis of such data as:

[1] Mr. Michael Gileadi is a senior associate with the Puerto Rico Nuclear Center and in charge of the Joint Radiation Survey Project. His present address is the Puerto Rico Nuclear Center, College Station, Mayaguez, Puerto Rico 00708.

a) The number and geographic distribution of diagnostic x-ray units being operated in Puerto Rico, classified according to ownership, manufacturer and model, total filtration, half value layer (HVL), kilovoltage (kVp), and maximal milliamperage values (mA).
b) The number of patients served by the unit, and the distribution of patients with respect to sex, age, and type of diagnostic x-ray procedure administered.

2. Determination of the radiation doses associated with each diagnostic procedure considered, and
3. Evaluation and interpretation of the indices enumerated above.

This method of working not only furnished answers to the questions concerning radiation hazards, but also, as a very valuable byproduct, yielded the first census of diagnostic x-ray equipment in Puerto Rico.

Detailed statistical data concerning the number of diagnostic x-ray examinations performed during a specified time interval on a certain unit were collected from the medical institutions and private offices surveyed (*5–6*). In addition, information was collected on the distribution of the examinations with respect to the type of procedure used and the distribution of patients with respect to sex and age groups.

Dose measurements were carried out both in vivo and on a Rando phantom using a variety of methods and instrumentation such as TLD-LiF powder, Victoreen chamber and DuPont SX-249-126 high sensitivity films.[2] Intercalibration of various dosimeters showed reasonable consistency of our dose measurements (*7–8*).

Finally, the dosimetric and statistical data obtained were combined with the vital statistics published by the Department of Health of the Commonwealth and used to compute the characteristic indices.

Data collection and evaluation were made on a regional basis, using the system of the Planning Board of the Commonwealth of Puerto Rico. This plan divides the Island into three regions based on relevant sociocultural and economic factors, as well as natural geographical boundaries. These regions (figure 1) are the following:

1. The northern region, which includes the city of San Juan (the political, cultural and economic capital of the island). The total population of this region is 1,767,200.
2. The southern region, which is highly industrialized with Ponce as the most important city and with a regional population of 493,500.
3. The western region, with Mayaguez as the most important city and with a total regional population of 420,200.

All demographic data quoted above refer to the year 1968.

Portions of the survey covering the western and southern regions (figure 2) were completed

[2] These films were developed and read in the Health Physics Division of Brookhaven National Laboratory.

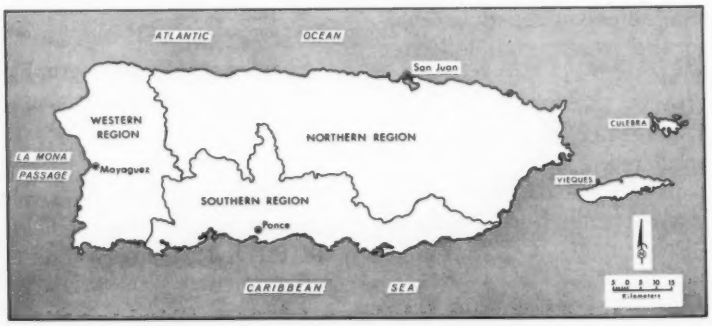

Figure 1. Puerto Rico and its subdivision in regions according to the planning board

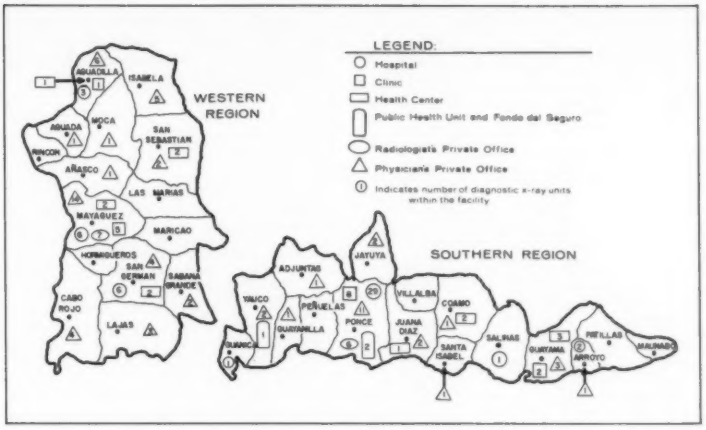

Figure 2. Distribution of diagnostic x-ray units in the western and southern regions of Puerto Rico, 1968

by 1969 (*7–8*). Some of the most significant results obtained in the survey are presented herewith.

Table 1 enables one to compare data concerning the southern and western regions in Puerto Rico for 1968. Because of the larger population in the southern region, it is natural that the number of diagnostic x-ray examinations is greater in the southern than in the western region (figures 3 and 4).

Table 1. Comparison of certain significant statistical results obtained in the joint radiation survey of the western and southern regions, Puerto Rico, 1968

Item	Southern region (population 493,500)	Western region (population 420,200)
Number of diagnostic x-ray units (excluding dental x-ray units)	83	78
Total number of abdominal diagnostic x-ray examinations within the "genetically significant" group	48,586	55,364
Total number of all thoracic diagnostic x-ray examinations	105,576	97,258
Total number of diagnostic x-ray examinations in public institutions only[a]	164,370	151,153
Total number of x-ray diagnostic examinations	217,732	215,197
Population per x-ray unit	5,945	5,387
Number of x-ray examinations per 100 patients in public institutions[a]	37.4	34.1

[a] The term "public institution" includes hospitals, clinics, health centers, and public health units.

Table 2 shows characteristic indices relating to radiation dose associated with diagnostic x-ray procedures considered within the southern region and the western region. A brief description of the

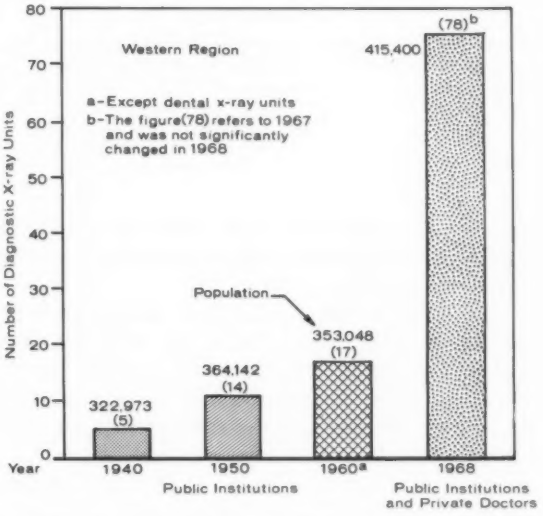

Figure 3. Variation of population and number of diagnostic x-ray units in the western region

derivation and interpretation of these indices follows.

The mean gonadal dose per abdominal diagnostic x-ray examination was derived from the measured gonadal dose associated with each type of abdominal diagnostic x-ray examination considered and from the number of such examinations performed annually within the region. The mean gonadal dose was computed as the weighted aver-

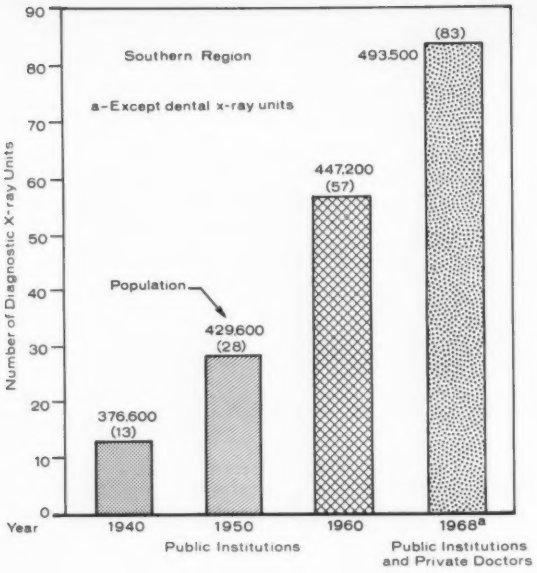

Figure 4. Variation of population and number of diagnostic x-ray units in the southern region

Table 2. Comparison of characteristic indices obtained for the western and southern regions in the radiation survey, Puerto Rico, 1968

Item	Southern region 1968 (population 493,500) (mrem)	Western region 1968 (population 420,200) (mrem)
Mean gonadal dose per abdominal diagnostic x-ray examination	443.6	424.8
Mean gonadal dose per thoracic diagnostic x-ray examination	1.04	1.14
Per capita per annum gonadal dose due to abdominal diagnostic x-ray examination	43.6	56.4
Per capita per annum gonadal dose due to thoracic diagnostic x-ray examination	.25	.26
Genetically significant dose due to diagnostic abdominal x-ray examinations	36.2	48.4
Genetically significant dose due to thoracic x-ray examinations	.2	.2

age of the measured doses with the pertinent numbers of diagnostic x-ray examinations used as statistical weights.

The mean gonadal dose thus computed is intended to be an indication of the radiation dose incurred on the average whenever a patient within the specified region (and time interval) undergoes an abdominal diagnostic x-ray test of any kind included within our survey.

The mean gonadal dose per thoracic examination was determined and interpreted in a similar fashion.

The per capita per annum gonadal dose per abdominal diagnostic x-ray examination was derived as follows. Using the measured doses for each abdominal x-ray procedure considered, the gonadal doses associated with diagnostic x-ray examinations delivered to all patients within the region during the specified year were added up and the grand total obtained was divided by the total population of the region.

The per capita per annum gonadal dose per thoracic diagnostic x-ray examination was derived in a similar fashion.

The genetically significant dose (GSD) was computed by means of the Penfil-Brown formula (*2*) using the dose measurements and detailed statistical data concerning age-sex distribution of patients for each type of examination considered as well as vital statistics of the Department of Health of the Commonwealth. The genetically significant dose characterizes the potential radiation damage imparted via genetic material to an average offspring that will be begotten after exposing the parent's gonads to ionizing radiation.

A survey of the northern region of Puerto Rico is now in process and is scheduled to be completed by the end of fiscal year 1971.

The recently approved survey of dental x-ray units and the possible health hazards associated with their use is proceeding under the joint sponsorship of the Puerto Rico Nuclear Center and the Department of Health of the Commonwealth of Puerto Rico with the cooperation of the School of Dentistry and the University of Puerto Rico.

It is hoped that with further development of social radiology in Puerto Rico, these two surveys will be followed by a general evaluation of hazards due to exposure to ionizing radiation of all kinds (x rays; radioactive sources used in industry, education, science, and medicine; ionizing radiation emitted by various electronic products; etc.) and that all suitable means will be used to reduce this total exposure to an unavoidable minimum.

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SECTION I. MILK AND FOOD

Milk Surveillance, June 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of meta-

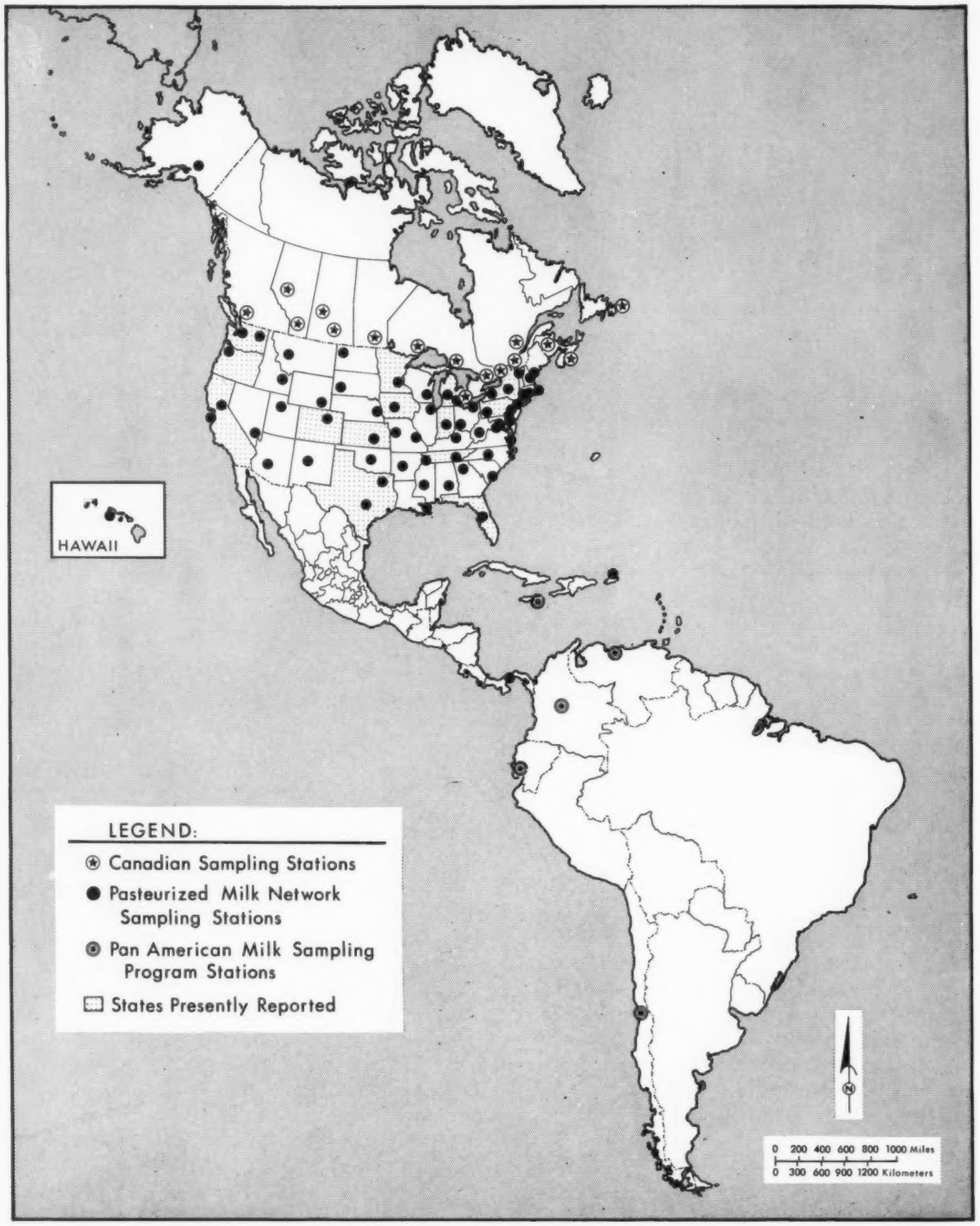

Figure 1. Milk sampling networks in the Western Hemisphere

bolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May–July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category			
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium 89: High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90: Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131: High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137 High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140: High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception to these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federation Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

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Table 2. Concentrations of radionuclides in milk for June 1971 and 12-month period, July 1970 through June 1971

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	NA	7	0	0	0	9
Alaska:	Palmer[c]	P	5	5	0	0	13	13
Ariz:	Phoenix[c]	P	NA	1	0	0	0	0
Ark:	Little Rock[c]	P	12	12	0	0	22	13
Calif:	Sacramento[c]	P	NA	1	0	0	0	0
	San Francisco[c]	P	NA	2	0	0	0	0
	Del Norte	P	20	16	0	0	10	11
	Fresno	P	2	2	0	0	2	1
	Humboldt	P	5	5	0	0	7	4
	Los Angeles	P	2	2	0	0	0	0
	Mendocino	P	6	5	0	0	4	4
	Sacramento	P	3	3	0	0	4	1
	San Diego	P	1	2	0	0	0	0
	Santa Clara	P	2	2	0	0	0	1
	Shasta	P	3	3	0	0	8	3
	Sonoma	P	3	3	0	0	9	3
Colo:	Denver[c]	P	NA	4	0	0	13	4
	West	R	NA		<0	<0	<0	<0
	Northeast	R	NA		NS	<0	NS	<0
	East	R	NA		NS	<0	NS	<0
	Southeast	R	NA		<0	<0	<0	<0
	South Central	R	NA		NS	<0	NS	<0
	Southwest	R	NA		<0	<0	25	<3
	Northwest	R	NA		<0	<5	<0	<0
Conn:	Hartford[c]	P	NA	7	0	0	0	11
	Central	P	8	6	0	0	14	16
Del:	Wilmington[c]	P	NA	9	0	0	13	8
D.C:	Washington[c]	P	NA	7	0	0	14	9
Fla:	Tampa[c]	P	5	5	0	0	43	47
	West	R	14	9	NA	0	NA	15
	North	R	8	9	0	0	27	26
	Northeast	R	NA	6	NA	0	NA	36
	Central	R	4	6	0	0	95	49
	Tampa Bay area	P	4	6	0	0	45	49
	Southeast	R	4	7	0	1	42	78
Ga:	Atlanta[c]	P	NA	11	0	0	16	14
Hawaii:	Honolulu[c]	P	3	3	0	0	0	0
Idaho:	Idaho Falls[c]	P	6	5	0	0	0	8
Ill:	Chicago[c]	P	8	7	0	0	17	11
Ind:	Indianapolis[c]	P	NA	7	0	0	12	8
	Northeast	P	7	9	0	0	20	15
	Southeast	P	7	10	0	0	30	14
	Central	P	6	8	0	5	20	12
	Southwest	P	7	11	0	0	30	12
	Northwest	P	5	10	0	0	20	13
Iowa:	Des Moines[c]	P	NA	7	0	0	15	4
	Iowa City	P	6	7	0	0	13	14
	Des Moines	P	7 (5)	8	0 (5)	0	9 (5)	11
	Spencer	P	8 (2)	6	0 (2)	0	15 (2)	9
	Fredericksburg	P	NS	NS	NS	NS	NS	NS
Kans:	Wichita[c]	P	NS	7	NS	0	NS	3
	Coffeyville	P	11	8	0	3	12	8
	Dodge City	P	7	7	0	0	10	2
	Falls City	R	NS	12	NS	5	NS	8
	Hays	P	9	10	0	4	12	5
	Kansas City	P	10	8	0	3	14	13
	Topeka	P	11	10	0	1	15	12
	Wichita	P	9	11	0	2	16	7
Ky:	Louisville[c]	P	NA	8	0	0	0	2
La:	New Orleans[c]	P	15	14	0	0	19	18
Maine:	Portland[c]	P	NA	10	0	0	19	21
Md:	Baltimore[c]	P	NA	8	0	0	0	7
Mass:	Boston[c]	P	11	9	0	0	15	20
Mich:	Detroit[c]	P	NA	8	0	0	17	11
	Grand Rapids[c]	P	NA	9	0	0	15	15
	Bay City	P	NS	7	NS	0	NS	13
	Charlevoix	P	8	10	<0 (5)	<1	22 (5)	16
	Detroit	P	7	7	<0	<0	11	9
	Grand Rapids	P	6	8	<0	<0	14	10
	Lansing	P	4	8	<0 (2)	<0	23 (2)	14
	Marquette	P	12	11	<0 (2)	<0	25 (2)	23
	Monroe	P	5	6	<0 (2)	<0	6 (2)	4
	South Haven	R	8	7	<0 (5)	<0	17 (5)	8
Minn:	Minneapolis[c]	P	NA	10	0	0	19	14
	Bemidji	P	9	7	0	0	17	22
	Mankato	P	7	5	0	0	11	11
	Rochester	P	11	7	0	0	15	11
	Duluth	P	23	15	0	0	33	28
	Worthington	P	6	5	0	0	11	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for June 1971 and 12-month period, July 1970 through June 1971—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
Minn:	Minneapolis	P	14	18	0	0	20	17
	Fergus Falls	P	9	6	0	0	16	14
	Little Falls	P	22	15	0	0	31	36
Miss:	Jackson[c]	P	NA	11	0	0	17	10
Mo:	Kansas City[c]	P	NA	7	0	0	12	3
	St. Louis[c]	P	NA	9	0	0	12	5
Mont:	Helena[c]	P	NA	5	0	0	15	11
Nebr:	Omaha[c]	P	NA	5	0	0	0	2
Nev:	Las Vegas[c]	P	NA	3	0	0	0	0
N.H:	Manchester[c]	P	NA	10	0	0	23	23
N.J:	Trenton[c]	P	NA	9	0	0	17	11
N. Mex:	Albuquerque[c]	P	NA	2	0	0	0	0
N.Y:	Buffalo[c]	P	9	7	0	0	0	12
	New York City[c]	P	NA	9	0	0	11	18
	Syracuse[c]	P	NA	7	0	0	0	11
	Albany	P	7	7	0 (4)	0	<0 (4)	0
	Buffalo	P	9	0	0	0	<0	0
	Massena	P	12	8	0 (3)	0	25 (3)	24
	Newburg	P	5	7	0 (2)	0	<0 (2)	0
	New York City	P	7	10	0	0	28	0
	Syracuse	P	3	4	0 (2)	0	<0	0
N.C:	Charlotte[c]	P	NA	11	0	0	18	13
N. Dak:	Minot[c]	P	NA	10	0	0	0	9
Ohio:	Cincinnati[c]	P	NA	7	0	0	0	2
	Cleveland[c]	P	NA	8	0	0	0	12
Okla:	Oklahoma City[c]	P	NA	6	0	0	14	7
Oreg:	Portland[c]	P	8	5	0	0	21	5
	Baker	P	NA	3	0	0	0	8
	Coos Bay	P	NA	6	0	0	0	10
	Eugene	P	NA	4	0	0	18	3
	Medford	P	NA	2	0	0	19	9
	Portland composite	P	NA	5	0	0	10 (2)	6
	Portland local	P	NA	4	0	0	10 (2)	9
	Redmond	P	NA	3	0	0	0	2
	Tillamook	P	NA	6	0	0	26	17
Pa:	Philadelphia[c]	P	NA	9	0	0	0	7
	Pittsburgh[c]	P	NA	11	0	0	16	14
	Dauphin	P	NS	6	0	1	18	14
	Erie	P	NS	9	0	0	NS	25
	Philadelphia	P	0	8	0	0	21	16
	Pittsburgh	P	7	12	0	1	15	21
R.I:	Providence[c]	P	NA	8	0	0	23	19
S.C:	Charleston[c]	P	8	9	0	1	24	15
S. Dak:	Rapid City[c]	P	NA	7	0	0	0	4
Tenn:	Chattanooga[c]	P	NA	8	0	0	14	9
	Memphis[c]	P	NA	7	0	0	14	9
	Chattanooga	P	NA	8	0	0	24	16
	Clinton	R	NA	9	0	0	29	17
	Fayetteville	P	NA	11	0	0	12	14
	Knoxville	P	NA	6	0 (3)	0	18 (3)	13
	Nashville	P	NA	6	0	0	17	11
Tex:	Austin[c]	P	NA	1	0	0	0	1
	Dallas[c]	P	NA	5	0	0	11	5
	Amarillo	R	NA		NA		NA	
	Corpus Christi	R	NA		NA		NA	
	El Paso	R	NA		NA		NA	
	Fort Worth	R	NA		NA		NA	
	Harlingen	R	NA		NA		NA	
	Houston	R	NA		NA		NA	
	Lubbock	R	NA		NA		NA	
	Midland	R	NA		NA		NA	
	San Antonio	R	NA		NA		NA	
	Texarkana	R	NA		NA		NA	
	Tyler	R	NA		NA		NA	
	Uvalde	R	NA		NA		NA	
	Wichita Falls	R	NA		NA		NA	
Utah:	Salt Lake City[c]	P	15	5	0	0	31	16
Vt:	Burlington[c]	P	NA	7	0	0	11	15
Va:	Norfolk[c]	P	NA	9	0	0	15	7
Wash:	Seattle[c]	P	NA	5	0	0	0	3
	Spokane[c]	P	NA	6	0	0	15	3
	Benton County	R	NS	1	NS	0	NS	2
	Franklin County	R	0	3	0	0	14	5
	Sandpoint, Idaho	R	17	12	0	0	34	22
	Skagit County	R	10	7	0	0	20	12
W. Va:	Charleston[c]	P	NA	8	0	0	12	8
Wisc:	Milwaukee[c]	P	NA	6	0	0	0	13
Wyo:	Laramie[c]	P	NA	5	0	0	0	1

See footnotes at end of table.

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Table 2. Concentration of radionuclides in milk for June 1971 and 12-month period, July 1970 through June 1971—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:							
Alberta: Calgary	P	8	7	(d)		24	19
Edmonton	P	6	8	(d)		22	22
British Columbia:							
Vancouver	P	8	9	(d)		33	23
Manitoba: Winnipeg	P	8	7	(d)		26	24
New Brunswick:							
Fredericton	P	11	12	(d)		21	25
Newfoundland:							
St. John's	P	16	17	(d)		50	32
Nova Scotia: Halifax	P	9	11	(d)		32	23
Ontario: Ottawa	P	3	6	(d)		17	16
Sault Ste. Marie	P	15	14	(d)		31	33
Thunder Bay	P	9	12	(d)		25	25
Toronto	P	9	5	(d)		20	12
Windsor	P	12	5	(d)		15	11
Quebec: Montreal	P	8	7	(d)		18	20
Quebec	P	11	10	(d)		21	29
Saskatchewan:							
Regina	P	7	7	(d)		13	14
Saskatoon	P	10	9	(d)		19	18
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	2	1	0	0	0	1
Chile: Santiago	P	2	0	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0	0	0
Jamaica: Montego Bay	P	5	4	0	0	60	50
Venezuela: Caracas	P	0	1	0	0	0	0
Canal Zone: Cristobal[c]	P	NA	1	0	0	0	10
Puerto Rico: San Juan[c]	P	NA	4	0	0	14	11
PMN network average[f]		9	7	0	0	11	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—15 pCi/liter
Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclides concentrations for the Pasteurized Milk Network stations denoted by footnote [c].

NA, no analysis.
NS, no sample collected.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed populations groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

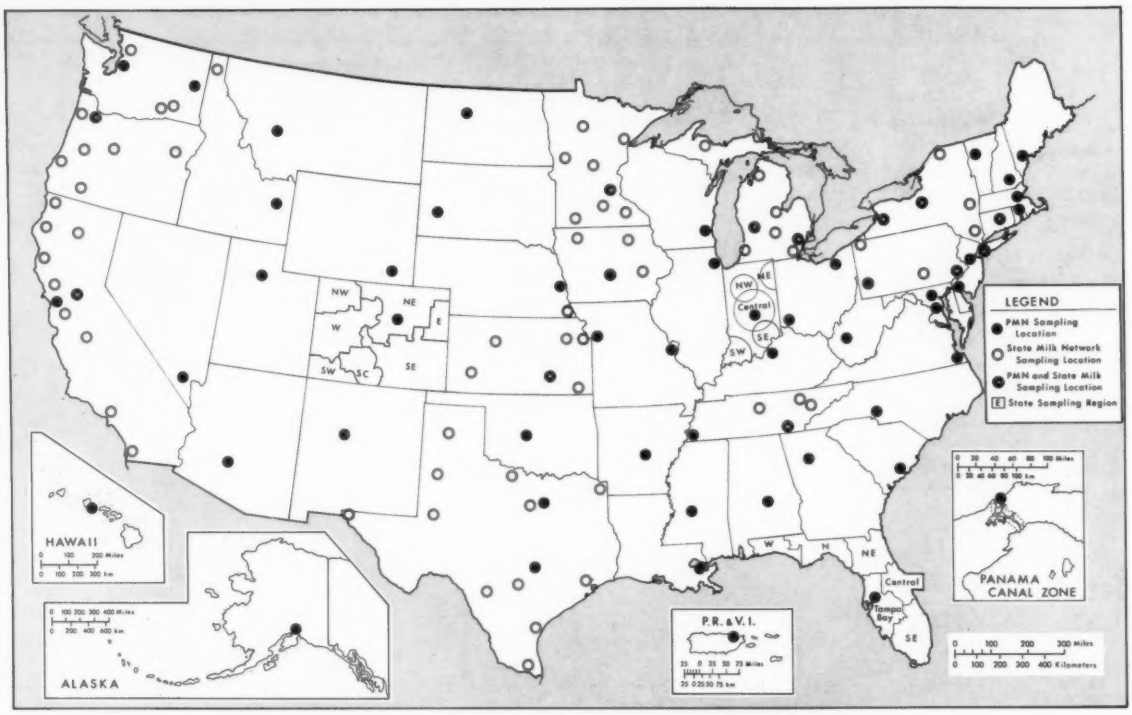

Figure 2. State and PMN milk sampling locations in the United States

Discussion of current data

In table 2, surveillance results are given for strontium-90, iodine-131, and cesium-137 for June 1971 and the 12-month period, July 1970 through June 1971. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for June 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89 or barium-140 was detected. The increase in the levels of strontium-89 at Santiago, Chile, is attributed to the recent French nuclear tests in the Pacific.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower guide levels established by the Federal Radiation Council, levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 23 pCi/liter in the United States for June 1971, and the highest 12-month average was 18 pCi/liter (Minneapolis, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from

Table 3. Strontium-89 and barium-140 in milk, June 1971

Sampling location		Radionuclide concentration (pCi/liter)	
		Strontium-89	Barium-140
Ark:	Little Rock (PMN)	6	
Calif:	Del Norte (State)	7	
	Humboldt (State)	6	
	Mendocino (State)	6	
	Shasta (State)	6	
	Sonoma (State)	6	
Ill:	Chicago (PMN)	9	
Kans:	Coffeyville (State)	10	
	Hays (State)	11	
	Kansas City (State)	8	
	Topeka (State)	17	13
	Wichita (State)	11	
Mass:	Boston (PMN)	6	
N.Y.:	Syracuse (State)	6	
Oreg:	Portland (PMN)	8	
Chile:	Santiago (PAHO)	[a]57	

[a] Attributed to French nuclear tests in the Pacific.

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0 to 95 pCi/liter in the United States for June 1971, and the highest 12-month average was 78 pCi/liter (Southeast Florida), representing 2.2 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1970	November 1970
Carbon-14 in Total Diet and Milk	July–December 1970	May 1971
Connecticut Standard Diet	July–December 1969	December 1970
Radionuclides in Institutional Diet Samples	January–March 1971	September 1971
Strontium-90 in Tri-City Diets	January–December 1969	June 1970

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	February 1971	October 1971
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January–December 1969	September 1970
Minnesota	July–December 1969	May 1971
North Carolina	January–December 1967	May 1969
New York	July–December 1969 and January–June 1970	September 1971
Radiostrontium in Tap Water, *HASL*	July–December 1970	October 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	January–March 1971	July 1971
Washington	July 1968–June 1969	February 1971

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, February 1971

Office of Water Programs
Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System formerly National Water Quality Network) of the Public Health Service. Currently, the program is operated by the Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Programs (Cincinnati, Ohio).

Table 1 presents the gross alpha and beta results for samples collected from four rivers during February 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of "Standard Methods for the Examination of Water and Wastewater" (*1*). Results are reported for the date of counting and are not corrected by extrapolation to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha and <1 pCi/liter for gross beta radioactivity measurements.

Table 1. Gross radioactivity in U.S. surface waters, February 1971

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Clinch River:					
Kingston, Tenn.	3	(<0.2, <0.2) <0.2	(<0.2, 2) <0.8	(<1, 1) <1	(9, 11) 10
Ohio River:					
Cincinnati, Ohio	1	<0.2	<0.2	1	3
Roanoke River:					
John Kerr Dam	2	(<0.2, <0.2) <0.2	(<0.2, 1) <0.6	(1, 1) <1	(4, 4) 4
St. Lawrence River:					
Massena, N.Y.	3	(<0.2, <0.2) <0.2	(<0.2, <0.2) <0.2	(<1, <1) <1	(6, 6) 6

[a] Where more than one sample is analyzed, the minimum and maximum values are in parentheses.

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(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition. New York, N.Y. (1971).

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Radioactivity in California Waters,[1] January-December 1969

Bureau of Radiological Health, State of California
Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the Sanitation and Radiation Laboratory of the State Department of Public Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters (table 1). It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

Most of the supplies sampled have raw surface waters (figure 1) as their source, although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500 ml samples are collected, and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Radioisotopic analyses are determined semiannually on composite samples. Gamma-ray emitting nuclides are determined by gamma-ray spectroscopy and radium and radiostrontium by chemical separation and counting.

[1] Data from July and October 1969 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

Figure 1. California surface water sampling stations

Sewage samples

Sewage samples are collected from many treatment plants throughout the State. Analyses of sewage effluent and sludge samples provide a means of monitoring to insure that industrial radioactive wastes discharged into sewage systems do not become excessive. The surveillance of sewage assumes greater importance as isotope licensees become more numerous and as the quantity per user increases. Analysis procedures for sewage samples are the same as the method used for domestic water. Gross radioactivity in sewage samples for January–December 1969 is presented in table 2.

The relationship between domestic water and sewage is of significance. One would expect a one-to-one radiological relationship between them unless there was some disposal of radioactive material into the sewage. The sewage to domestic water ratio has been calculated for those places where both samples are collected and analyzed. The data are in table 3. In addition to the ratio, the difference in the concentration of radioactive material in sewage and water was determined.

Looking at either the sewage-water ratio or the difference, it is apparent that some sewages in the State contain no additional radioactivity in the sewage as compared to its domestic water, and

Table 1. Gross beta radioactivity in California domestic waters, January–December 1969

Sampling station	Quality	Concentration[a] (pCi/liter)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Alturas	Well	31	13	8	0	0	10	8	5	17	15	NS	20
Antioch	Treated	19	17	0	8	0	0	NS	NS	2	10	NS	NS
Lake Arrowhead	Treated	25	7	10	NS	NS	NS	0	NS	NS	6	13	17
Berkeley	Treated	7	7	0	7	8	5	8	NS	7	0	2	22
Clearlake Highlands	Treated	1	28	3	12	10	9	NS	0	1	26	0	20
Crescent City	Well	0	0	1	7	0	3	3	0	NS	0	NS	2
Death Valley	Treated	32	1	16	16	4	NS	NS	NS	NS	NS	NS	35
Dos Palos	Treated	0	0	9	13	0	19	0	0	8	8	0	1
El Centro	Treated	NS	NS	NS	NS	NS	NS	NS	NS	11	18	NS	NS
Eureka	Raw	0	0	1	4	0	6	5	8	0	1	0	0
	Treated	5	42	14	0	8	18	NS	NS	NS	NS	NS	NS
Livermore	Well	NS	NS	NS	NS	6	0	4	NS	7	0	0	10
Los Angeles	Raw	NS	NS	19	NS	1	0	0	30	20	3	21	6
Marin Municipal Water District	Treated	13	35	3	2	0	5	5	3	6	9	0	0
Metropolitan Water District of Southern Calif.	Treated	28	28	0	25	18	19	51	96	36	35	30	21
Lake Millerton	Raw	7	2	0	14	0	7	5	NS	5	10	6	NS
Monterey	Treated	14	0	7	0	7	1	NS	2	NS	5	20	10
Napa	Treated	11	6	NS	NS	0	8	10	NS	13	12	0	13
Needles	Well	NS	NS	14	NS	NS	2	8	5	10	NS	NS	NS
North Marin Water District	Treated	6	NS	NS	9	2	19	NS	NS	NS	NS	NS	NS
	Raw	11	0	7	NS	NS	NS	13	NS	0	6	19	13
	Sludge[b]	16	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Oroville	Treated	0	12	4	10	3	5	NS	NS	0	NS	NS	NS
Wyandotte Irrigation District	Raw	NS	NS	NS	NS	NS	NS	0	NS	14	4	NS	NS
	Treated	NS	NS	NS	NS	NS	NS	NS	NS	0	NS	23	12
Pleasanton	Well	0	7	15	3	2	8	NS	NS	NS	NS	NS	NS
	Treated	NS	NS	NS	NS	NS	NS	5	3	4	0	0	16
Redding	Treated	17	7	6	11	10	44	0	4	3	0	0	13
Sacramento:													
American River	Treated	0	8	NS	11	0	NS	NS	NS	NS	NS	NS	NS
Sacramento	Treated	8	1	NS	11	4	NS	8	NS	0	17	13	NS
San Diego	Raw	0	0	7	24	23	3	8	NS	NS	NS	NS	NS
	Treated	23	10	NS	18	14	23	0	NS	NS	NS	NS	NS
San Francisco	Raw	6	4	80	10	10	0	NS	9	11	11	0	14
San Jose	Raw	0	NS	14	0	7	9	0	8	0	2	14	NS
Santa Barbara	Treated	0	9	20	12	6	7	6	2	14	14	0	0
Santa Cruz	Raw	0	0	0	0	0	5	0	0	8	1	0	0
	Treated	NS	NS	NS	NS	NS	NS	11	15	14	3	11	8
Santa Rosa	Well	NS	NS	NS	2	11	6	6	3	3	0	0	0
Scotia	Treated	6	11	22	6	7	20	NS	9	0	5	NS	NS
Tahoe City	Raw	NS	7	9	3	NS	NS	0	NS	NS	NS	NS	NS
Ukiah	Well	0	7	0	5	0	NS	8	7	11	1	23	NS
Vallejo	Treated	15	0	1	7	0	0	18	15	31	0	10	23
Willits	Treated	15	32	5	0	0	5	4	11	7	2	3	8
Yosemite	Treated	29	0	19	16	0	3	1	11	20	16	NS	9
Maximum		32	42	80	25	23	44	51	96	36	35	30	35
Minimum		0	0	0	0	0	0	0	0	0	0	0	0

[a] Levels below the practical reporting level (15 pCi/liter) should be regarded as statistically insignificant.
[b] Sludge reported in pCi/g (dry weight).
NS, no sample.

some sewages do contain additional radioactive material.

Tables 4 and 5 show a comparison of gross beta yearly average concentrations in sewage effluent and sludge for 1964 through 1969.

Discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface water supplies in California for January–December 1969. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, alpha radioactivity analyses are not presented. No increase in radioactivity level of surface water has been observed.

REFERENCE

(1) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59–6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 15, 1959).

Recent coverage in *Radiological Health Data and Reports*

Period	Issue
July–December 1968	August 1970

Table 2. Gross radioactivity in California sewage samples, January–December 1969

Sewage treatment plant	Concentration (pCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Antioch:												
Effluent:												
Alpha	0	1	6	0	0	0	NS	NS	NS	1	NS	0
Beta	0	0	36	29	0	0	NS	NS	NS	4	NS	0
Sludge:												
Alpha	0	20	0	1	9	10	NS	NS	NS	5	7	2
Beta	24	0	15	41	0	0	NS	NS	NS	9	6	15
Bakersfield:												
Effluent:												
Alpha	3	1	0	0	0	0	0	1	1	0	0	0
Beta	0	0	18	35	5	0	2	26	15	0	21	1
Sludge:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
El Centro:												
Effluent:												
Alpha	13	0	22	0	6	5	NS	0	18	0	2	0
Beta	28	9	1	10	8	0	NS	10	0	28	2	2
Sludge:												
Alpha	41	20	17	10	10	26	27	17	29	6	20	29
Beta	27	91	27	14	9	23	31	43	33	22	29	14
Eureka[a]												
Effluent:												
Alpha	1	5	NS	0	NS	NS	13	0	4	NS	NS	NS
Beta	0	0	NS	20	NS	NS	57	19	0	NS	NS	NS
Sludge:												
Alpha	14	3	0	7	NS	NS	3	0	2	NS	NS	NS
Beta	0	67	0	27	NS	NS	0	7	1	NS	NS	NS
Fresno:												
Effluent:												
Alpha	2	4	0	5	1	2	2	1	1	0	1	0
Beta	0	20	2	0	6	0	0	48	10	61	40	27
Sludge:												
Alpha	8	18	25	11	0	13	13	12	4	13	7	14
Beta	0	15	13	25	5	39	52	13	27	2	26	29
Livermore:												
Effluent:												
Alpha	0	0	0	6	2	0	0	0	0	0	2	3
Beta	4	0	19	9	6	21	21	43	70	20	37	40
Sludge:												
Alpha	6	12	14	6	21	8	8	11	0	17	13	44
Beta	141	52	23	102	417	235	243	218	539	16	185	401
Los Angeles City:												
Hyperion:												
Effluent:												
Alpha	5	16	22	9	13	11	18	0	0	5	2	4
Beta	0	10	33	18	12	20	50	31	20	1	8	13
Sludge:												
Alpha	9	8	15	10	11	15	12	3	12	0	5	10
Beta	14	11	10	7	19	0	4	19	19	25	31	28
Los Angeles County:												
Sanitary District:												
Effluent:												
Alpha	0	0	0	9	0	0	0	0	0	NS	4	13
Beta	0	0	28	17	18	0	0	26	28	NS	58	26
Sludge:												
Alpha	10	12	11	4	3	6	7	NS	2	9	18	5
Beta	6	27	11	13	1	0	22	NS	18	23	17	0
Oakland-East Bay mud:												
Effluent:												
Alpha	NS	0	NS	NS	0	NS	NS	0	0	0	0	5
Beta	NS	0	NS	NS	52	NS	NS	37	7	0	8	41
Sludge:												
Alpha	NS	17	NS	NS	12	NS	NS	0	8	NS	13	NS
Beta	NS	16	NS	NS	10	NS	NS	21	16	NS	18	NS
Orange County:												
Plant 1:												
Effluent:												
Alpha	2	0	0	11	17	3	0	0	NS	NS	NS	NS
Beta	0	54	55	17	0	20	36	42	NS	NS	NS	NS
Sludge:												
Alpha	28	18	5	21	15	4	7	0	NS	NS	NS	NS
Beta	20	0	18	0	23	0	1	25	NS	NS	NS	NS
Orange County:												
Plant 2:												
Effluent:												
Alpha	11	0	7	4	36	3	7	2	NS	NS	NS	NS
Beta	8	29	0	30	1	1	35	16	NS	NS	NS	NS

See footnotes at end of table.

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Table 2. Gross radioactivity in California sewage samples, January–December 1969—Continued

Sewage treatment plant	Concentration (pCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Orange County:												
Plant 2: (Continued)												
Sludge:												
Alpha	26	12	5	39	18	12	9	18	NS	NS	NS	NS
Beta	0	24	18	0	35	9	3	56	NS	NS	NS	NS
Pleasanton:[a]												
Effluent:												
Alpha	5	20	7	2	2	5	7	4	6	14	5	0
Beta	29	24	55	23	14	19	45	69	37	98	62	133
Sludge:												
Alpha	109	102	71	85	80	72	67	49	47	33	56	53
Beta	171	113	121	192	313	217	160	222	354	363	418	276
Sacramento:												
Effluent:												
Alpha	0	0	16	2	1	0	4	1	NS	0	8	1
Beta	0	0	36	3	16	0	0	22	NS	1	2	12
Sludge:												
Alpha	29	17	3	7	7	12	8	5	NS	11	4	13
Beta	8	15	17	15	3	10	20	28	NS	19	14	23
Salinas:												
Effluent:												
Alpha	0	4	48	10	12	0	0	0	0	8	17	2
Beta	15	0	0	4	0	41	41	53	46	13	41	18
Sludge:												
Alpha	19	61	10	8	17	7	8	13	15	6	8	9
Beta	16	0	38	0	13	16	24	19	72	25	47	30
San Bernardino:												
Effluent:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sludge:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
San Diego:												
Effluent:												
Alpha	13	10	1	1	2	13	0	1	5	NS	1	15
Beta	0	13	42	23	4	21	36	21	84	NS	34	44
Sludge:												
Alpha	NS	6	0	15	22	14	14	14	16	NS	30	17
Beta	NS	11	3	30	42	13	26	35	20	NS	40	7
San Francisco:												
North Point:												
Effluent:												
Alpha	12	0	0	0	7	2	0	0	35	0	0	0
Beta	13	27	0	22	27	8	23	10	46	34	67	12
Sludge:												
Alpha	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Beta	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Richmond Sunset:												
Effluent:												
Alpha	0	6	0	0	0	0	0	0	0	0	0	0
Beta	0	0	26	10	55	0	0	9	17	8	11	0
Sludge:												
Alpha	13	5	4	6	4	9	9	21	0	NS	9	11
Beta	0	34	15	15	10	0	4	35	23	NS	39	13
Southeast:												
Effluent:												
Alpha	0	12	19	0	0	0	0	0	0	1	0	19
Beta	23	38	26	24	19	25	40	0	0	24	0	42
Sludge:												
Alpha	19	15	3	7	0	19	NS	14	13	NS	3	NS
Beta	15	34	25	18	26	0	NS	15	18	NS	8	NS
San Jose:												
Effluent:												
Alpha	NS	42	NS	1	14	8	NS	0	0	NS	2	NS
Beta	NS	1	NS	1	20	5	NS	5	11	NS	18	NS
Sludge:												
Alpha	NS	12	NS	16	10	59	59	24	9	NS	NS	13
Beta	NS	84	NS	154	215	412	478	223	8	NS	NS	25
Vallejo:												
Effluent:												
Alpha	0	11	2	6	1	0	1	1	0	0	10	0
Beta	20	52	50	23	12	8	26	6	38	12	14	7
Sludge:												
Alpha	6	7	6	13	3	6	22	2	4	3	11	3
Beta	9	8	9	0	9	10	6	0	20	0	24	0

[a] Average of Hill, McCullen, and Murray Street treatment plants.
[b] Average of triplicate samples.
NS, no sample.

Table 3. Comparison of gross beta radioactivity in domestic water and sewage effluent in California, 1969

Sampling station	Average concentration (pCi/liter)			Sewage to water ratio
	Domestic water	Sewage effluent	Difference	
Antioch	7	9	2	1.3
East Bay mud	7	20	13	2.9
Eureka	10	16	6	1.6
Livermore	4	24	20	6.0
Los Angeles City	13	18	5	1.4
Pleasanton	5	51	46	10.2
Sacramento	6	8	2	1.3
San Diego	9	29	20	3.2
San Francisco:				
North Point	12	24	12	2.0
Richmond Sunset	12	12	0	1.0
South East	12	22	10	1.8
San Jose	7	9	2	1.3
Vallejo	7	22	15	3.1

Table 4. Gross beta radioactivity in California sewage effluent, 1964–1969

Treatment plant	Average concentration (pCi/liter)						6-year-average
	1964	1965	1966	1967	1969	1969	
Antioch	35	15	8	14	3	9	14
Bakersfield	47	41	2	18	9	10	21
El Centro	18	11	15	29	24	9	18
Eureka	89	23	9	7	9	16	26
Fresno	15	25	7	8	12	18	14
Livermore	22	35	29	24	32	24	28
Los Angeles City:							
Hyperion	18	NS	18	20	12	18	18
Los Angeles County	20	29	30	38	19	18	31
East Bay mud	29	28	27	14	27	20	24
Orange County:							
Plant 1	33	25	19	37	21	28	27
Plant 2	95	30	22	36	25	15	37
Pleasanton	124	34	33	29	21	51	49
Sacramento	19	7	8	21	22	8	14
Salinas	16	12	20	NS	11	23	18
San Diego	36	26	48	36	NS	29	37
San Francisco:							
North Point	45	11	18	25	12	24	23
Richmond Sunset	28	15	20	9	11	12	16
Southeast	67	70	38	46	28	22	45
San Jose	26	23	17	12	31	9	20
Vallejo	26	17	16	12	13	22	18

NS, no sample.

Table 5. Gross beta radioactivity in sludge in California sewage treatment plants, 1964–1969

Treatment plant	Average concentration (pCi/dry g)						6-year-average
	1964	1965	1966	1967	1968	1969	
Antioch	20	12	10	44	8	14	18
El Centro	37	20	15	21	21	30	24
Eureka	28	22	8	1	7	15	14
Fresno	52	15	15	28	17	21	25
Livermore	76	64	54	95	85	214	98
Los Angeles City:							
Hyperion	9	NS	26	22	14	16	17
Los Angeles County	15	15	23	13	7	13	14
East Bay mud	46	20	16	14	8	16	20
Orange County:							
Plant 1	56	29	20	22	5	11	24
Plant 2	35	29	15	31	19	20	25
Pleasanton	460	400	576	320	210	244	370
Sacramento	30	14	14	19	12	15	17
Salinas	30	42	21	NS	16	25	27
San Diego	54	27	18	19	24	21	27
San Francisco:							
Richmond Sunset	62	65	24	26	18	17	35
Southeast	46	30	34	36	28	18	32
San Jose	40	14	25	91	164	200	89
Vallejo	55	23	13	13	10	8	20

NS, no sample.

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Radiostrontium in Tap Water, July-December 1970

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137 to strontium-90 ratios in New York City tap water for July through December 1970 are presented in table 1. These results appear graphically in figure 1.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL 243. This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Radiostrontium in New York City tap water July-December 1970

Sampling months 1970	Strontium-90[a] (pCi/liter)	$^{137}Cs/^{90}Sr$
July	0.72	0.13
August	.64	.14
September	.64	.13
October	.62	.14
November	.70	.14
December	.68	.11

[a] Approximately 100 liters per sample.

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures, 40:E-38-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1, Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154-2155. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1970	April 1971

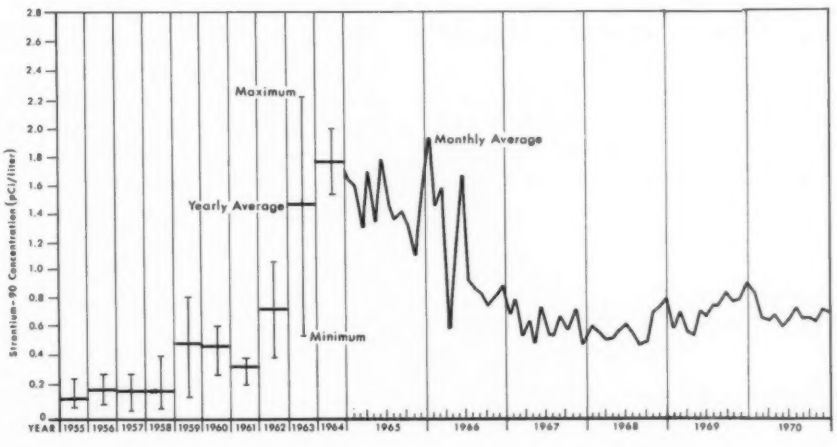

Figure 1. Strontium-90 concentrations in New York City tap water, 1955–December 1970

XUM

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports.*

Network	Period	Issue
Fallout in the United States and other Areas, *HASL*	July–December 1968 and January–December 1969	January 1971
Plutonium in Airborne Particulates and Precipitation	July–December 1970	June 1971
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January–December 1968	April 1971
Mexican Air Monitoring Program	July 1970	November 1970

1. Radiation Alert Network June 1971

National Environmental Research Laboratory
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of the stations are operated by State Health Department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Data Acquisition and Analysis Branch, Division of Air Quality and Emission Data, EPA, Durham, N.C. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during June 1971.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	3	1	2	4	479	4	479	68
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	30	1	0	0	0				
	Fairbanks	5	2	0	1	0				
	Juneau	19	4	0	1	1	4	1	4	2
	Kodiak	4	0	0	0	0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	11	6	2	3	0				
Ark:	Little Rock	13	1	0	1	0				
Calif:	Berkeley	21	1	0	0	0				
	Los Angeles	22	2	0	1	0				
C.Z:	Ancon	17	0	0	0	0				
Colo:	Denver	20	5	2	3	2	8	(b)		
Conn:	Hartford	22	1	0	1	5	47	5	47	10
Del:	Dover	22	2	0	1	0				
D.C:	Washington	24	1	0	1	0				
Fla:	Jacksonville	22	2	0	1	9	125	9	125	30
	Miami	21	1	0	0	7	110	7	110	0
Ga:	Atlanta	16	2	1	1	1	15	1	15	26
Guam:	Agana	0				0				
Hawaii:	Honolulu	25	1	0	0	4	69	(b)		
Idaho:	Boise	4	2	1	1	2	5	2	5	1
Ill:	Springfield	0				0				
Ind:	Indianapolis	22	2	0	1	0				
Iowa:	Iowa City	20	5	1	2	3	49	3	49	0
Kans:	Topeka	22	4	1	2	11	98	11	98	3
Ky:	Frankfort	0				0				
La:	New Orleans	19	1	0	1	10	162	(b)		
Maine:	Augusta	22	1	0	1	7	90	7	90	0
Md:	Baltimore	22	2	0	1	5	50	5	50	0
Mass:	Lawrence	22	2	0	1	6	88	6	88	14
	Winchester	21	3	0	1	4	52	4	52	0
Mich:	Lansing	21	2	1	1	6	101	6	101	13
Minn:	Minneapolis	22	3	0	1	5	96	5	96	22
Miss:	Jackson	12	2	0	1	1	16	1	16	5
Mo:	Jefferson City	22	4	1	1	7	96	7	96	1
Mont:	Helena	15	2	0	1	5	40	5	40	0
Nebr:	Lincoln	19	8	1	4	4	41	4	41	17
Nev:	Las Vegas	22	4	1	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	2	0	1	7	56	7	56	9
N. Mex:	Santa Fe	20	3	0	1	0				
N.Y:	Albany	22	2	0	1	2	29	2	29	28
	Buffalo	21	2	1	1	0				
	New York City	0				0				
N.C:	Gastonia	16	10	1	4	5	71	(b)		
N. Dak:	Bismarck	21	3	1	1	10	147	10	147	17
Ohio:	Cincinnati	0				0				
	Columbus	4	3	1	1	0				
	Painesville	22	3	1	2	6	123	6	123	305
Okla:	Oklahoma City	3	1	1	1	0				
	Ponca City	20	5	0	1	6	139	6	139	0
Oreg:	Portland	20	1	0	0	9	59	9	59	5
Pa:	Harrisburg	12	3	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	21	1	0	1	3	21	3	21	0
S.C:	Columbia	20	3	0	1	4	100	4	100	0
S. Dak:	Pierre	22	4	1	2	0				
Tenn:	Nashville	21	3	0	1	8	98	8	98	17
Tex:	Austin	0				0				
	El Paso	19	3	1	1	0				
Utah:	Salt Lake City	27	3	1	1	2	9	2	9	6
Vt:	Barre	22	5	1	2	6	47	6	47	5
Va:	Richmond	20	2	0	1	4	137	4	137	59
Wash:	Seattle	9	0	0	0	9	53	(b)		
	Spokane	9	1	0	1	0				
W. Va:	Charleston	21	3	0	1	10	98	10	98	14
Wisc:	Madison	21	4	0	1	5	72	5	72	12
Wyo:	Cheyenne	22	9	1	3	1	2	1	2	4
Network summary		1,100	10	0	1	206	91	5	81	20

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] June 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for June 1971 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	24	0.5	0.4	0.5	63	6.03
Coral Harbour	4	.2	.1	.2	355	4.32
Edmonton	17	.5	.4	.4	91	11.88
Ft. Churchill	4	.2	.1	.1	205	10.01
Fredericton	4	.4	.1	.3	180	15.96
Goose Bay	4	.2	.1	.2	66	6.86
Halifax	61	.4	.3	.3	235	13.51
Inuvik	4	.2	.1	.1	169	2.17
Montreal	4	.5	.3	.4	248	11.89
Moosonee	4	.5	.1	.3	39	3.47
Ottawa	4	.5	.4	.4	96	5.22
Quebec	4	.5	.3	.4	253	24.66
Regina	4	1.3	.3	.6	106	8.05
Resolute	4	.2	.0	.1	106	.54
St. John's, Nfld.	4	.6	.2	.4	156	14.63
Saskatoon	4	.4	.3	.4	206	19.05
Sault Ste. Marie	2	.4	.3	.4	196	21.32
Thunder Bay	4	.4	.3	.3	244	17.29
Toronto	4	.5	.2	.3	427	25.21
Vancouver	4	.3	.2	.2	275	17.87
Whitehorse	4	.4	.3	.4	264	13.88
Windsor	4	.4	.3	.3	257	4.49
Winnipeg	4	.5	.4	.4	399	30.23
Yellowknife	4	.2	.1	.1	366	4.55
Network summary	184	1.3	0.0	0.3	208	12.21

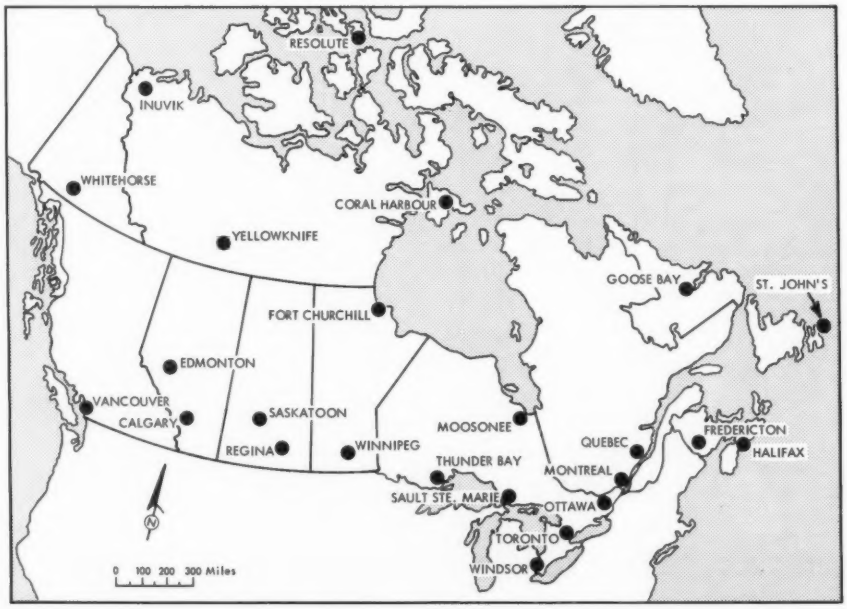

Figure 2. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program June 1971

Pan American Health Organization and *Environmental Protection Agency*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The June 1971 air monitoring results from the participating countries are given in table 3. The increased levels of radioactivity are attributed to the recent French nuclear tests in the Pacific.

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, June 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average[a]
Argentina: Buenos Aires	0			
Bolivia: La Paz	0			
Chile: Santiago	29	4.20	0.01	0.83
Colombia: Bogota	9	.16	.01	.06
Ecuador: Cuenca	0			
Guayaquil	20	2.10	.02	.57
Quito	0			
Guyana: Georgetown	0			
Jamaica: Kingston	0			
Peru: Lima	24	2.66	.03	.73
Venezuela: Caracas	4	.40	.13	.36
West Indies: Trinidad	19	.81	.12	.47
Pan American summary	105	4.20	0.01	0.61

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

3. Mexican Air Monitoring Program August–December 1970 and January 1971

National Commission of Nuclear Energy México, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four sta-

Figure 4. Mexican air sampling locations

Table 4. Mexican gross beta radioactivity of airborne particulates, August 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	11	0.10	0.03	0.06
Chihuahua	17	.45	.05	.18
Ciudad Juarez	NS			
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	9	.40	.06	.17
México, D.F.	10	.14	.03	.08
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	22	.37	.10	.21
Veracruz	11	.30	.03	.14

NS, no sample, station temporarily shutdown.

Table 5. Mexican gross beta radioactivity of airborne particulates, September 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	12	0.13	0.03	0.05
Chihuahua	4	.14	.06	.10
Ciudad Juarez	7	.49	.25	.38
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	NS			
México, D.F.	8	.08	.03	.05
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	19	.17	.05	.11
Veracruz	20	.32	.03	.10

NS, no sample, station temporarily shutdown.

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tions are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency, 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 to 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

Table 6. Mexican gross beta radioactivity of airborne particulates, October 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	15	0.13	0.03	0.08
Chihuahua	19	.48	.07	.23
Ciudad Juarez	NS			
Ensenada	7	.43	.11	.23
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	3	NA	NA	NA
México, D.F.	9	.13	.06	.10
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	17	.39	.08	.21
Veracruz	18	.27	.04	.13

NS, no sample, station temporarily shutdown.
NA, no analysis.

Table 7. Mexican gross beta radioactivity of airborne particulates, November 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	17	0.18	0.05	0.11
Chihuahua	16	.26	.12	.18
Ciudad Juarez	7	.42	.18	.30
Ensenada	2	.19	.15	[a]
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	NS			
Mérida	8	.46	.17	.23
México, D.F.	8	.13	.04	.09
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	17	.33	.09	.19
Veracruz	9	.09	.03	.06

[a] Average not calculated.
NS, no sample, station temporarily shutdown.

Table 8. Mexican gross beta radioactivity of airborne particulates, December 1970

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	15	0.24	0.09	0.15
Chihuahua	8	.30	.11	.17
Ciudad Juarez	NS			
Ensenada	4	.32	.12	.22
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	12	.38	.07	.20
Mazatlan	NS			
Mérida	4	.30	.10	.16
México, D.F.	NS			
Nuevo Laredo	1	NA	NA	
San Luis Potosí	NS			
Tampico	15	.47	.06	.19
Torreón	14	.29	.07	.17
Veracruz	NS			

NS, no sample, station temporarily shutdown.
NA, no analysis.

The maximum, minimum, and average beta radioactivity in surface air during August through December 1970 and January 1971 are presented in tables 4 through 9.

Table 9. Mexican gross beta radioactivity of airborne particulates, January 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	17	0.31	0.10	0.18
Chihuahua	7	.92	.07	.37
Ciudad Juarez	NS			
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	2	.13	.12	[a]
Mazatlan	NS			
Mérida	10	.54	.08	.25
México, D.F.	12	.15	.06	.10
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	15	.22	.06	.14
Torreón	8	.47	.13	.25
Veracruz	3	.17	.16	[a]

[a] Average not calculated
NS, no sample, station temporarily shutdown.

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(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comision Nacional de Energia Nuclear, Direccion General de Seguridad Radiologica (1966).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follows for the Lawrence Radiation Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Lawrence Radiation Laboratory[2] July–December 1970

University of California
Berkeley, Calif.

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is situated on the western slope of the range of hills running along the eastern side of San Francisco Bay. The laboratory area is largely separate from the main campus of the University (figure 1).

To the north and south of the laboratory area are residential areas of the cities of Berkeley and Oakland. The Berkeley campus of the University of California is on the west; to the east, are the Lawrence Hall of Science and the Space Sciences Laboratory, beyond them lies uninhabited watershed land and the Tilden Regional Park.

The most prevalent wind direction is westerly. During the summer months, the afternoon sea breeze establishes a very pronounced prevailing westerly wind direction. At other times, the direction is less predictable. Annual rainfall is 23 inches, almost all of which falls between November

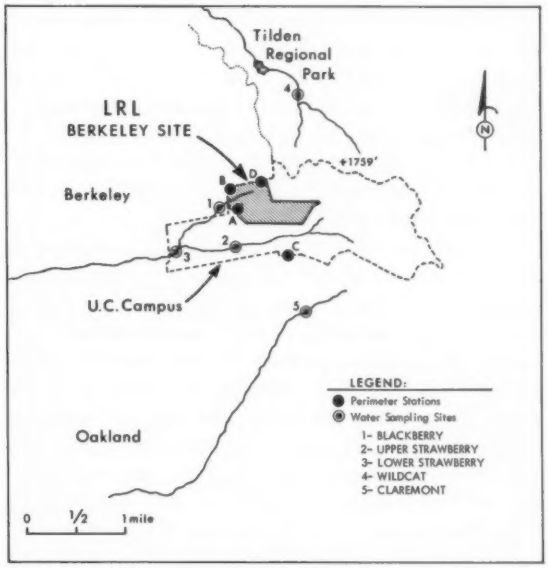

Figure 1. Environmental sampling locations at the Berkeley site, Lawrence Radiation Laboratory

[2] Summarized from "Results of Environmental Radioactivity Sampling Program, July–December 1970," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif. 94720.

1 and May 1. The prevailing wind direction during precipitation is southerly.

The laboratory carries on a wide ranging program of general research in the fields of both physical and biological sciences. Facilities include a number of large accelerators, and various physics, chemistry, biology, and medical research laboratories.

The basic policy at LRL has long been to prevent, as far as possible, any release of radioactive material to the environment, no matter how small. No deliberate releases are sanctioned, except where no practical method for containment has yet been developed, and quantities are small compared with standards established by the International Commission on Radiological Protection (ICRP) and the Atomic Energy Commission (AEC).

The most sensitive measurements of releases are those taken closest to the source itself, before dilution makes detection of small quantities more difficult. The stack sampling program, therefore, provides the most useful information for controlling releases to the atmosphere. Over 100 separate exhausts from hoods and glove-box manifolds are sampled. The total quantity released from these stacks during July–December 1970 was 300 nCi of alpha radioactivity, 420 mCi of carbon-14, 18.3 curies of tritium and 53 μCi of other beta-particle emitters. The average concentrations in the total exhaust, before any dilution by the atmosphere, was 25 percent of the maximum permissible concentrations for offsite breathing zone air, as given by the ICRP.

In addition to the careful sampling of stacks, an environmental air sampling program is also carried on to make sure no undetected releases occur. These samples provide a direct measurement of possible exposure to the nearby population. The sampling stations designated "local area" are scattered around the site and provide samples of the atmosphere on the site itself. The "perimeter" samples are taken at the boundary line of University property, in the direction of populated areas. From the results of these samples, there appears to have been no significant exposure from radioactive materials released by LRL. The levels of radioactivity observed in each type of sample are presented in table 1.

At each of these environmental stations, rain or dry fallout is also collected. Open 15-inch-diameter polyethylene bags form the collecting vessel. If no rain has fallen, the bags are rinsed out with water to obtain a sample. Since on the average, the more remote perimeter stations show about the same radioactivity as the nearer ones, the radioactivity does not result from laboratory operations. The radioactivity levels in samples collected at each location are summarized in table 2.

Table 1. Atmospheric monitoring, LRL Berkeley site July–December 1970

Sampling locations (number of locations)	Number of samples	Average concentration (pCi/m³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (10)	258	0.000	<0.005	0.16	0.50
Perimeter					
A:	26	.000	.005	.15	.48
B:	23	.000	< .005	.16	.40
C:	26	.000	< .005	.16	.44
D:	24	.000	< .005	.19	.41
Summary	99	.000	< .005	.16	.48

Table 2. Total deposition, LRL Berkeley site July–December 1970

Sampling locations (number of locations)	Number of samples	Average deposition (nCi/m²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Local area (10)	54	0.008	0.046	2.99	4.01
Perimeter (4)	24	.000	.019	3.73	4.86

All liquid waste known to be radioactive is collected, solidified, and shipped away. Other liquid wastes are discharged directly to the municipal sewer system. Occasionally, small quantities of radioisotopes are accidentally released to the sewer system. There are two outfalls, each of which is monitored by a continuous proportional sampling system to insure that no significant quantities have been discharged (table 3). The total concentration (alpha-plus-beta radioactivity) in sewage is only 31 percent of the standard for drinking water and therefore does not constitute an exposure threat.

The storm drainage from the laboratory flows into the surface stream system. These surface streams are exposed as they run through the University property and are sampled at three places.

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Table 3. Summary of sewer data, LRL Berkeley site, July–December 1970

Sewer	Total quantities discharged 6 months			Net concentrations (pCi/liter)				
	Total volume (M1)	Total alpha radioactivity (μCi)	Total beta radioactivity (mCi)	Number of samples	Alpha		Beta	
					Average	Maximum	Average	Maximum
Hearst	119.3	11.3	4.30	24	0.09	3.2	36.1	185
Strawberry	38.4	2.4	.49	24	.06	1.8	12.7	25
Summary	157.7	13.7	4.79		0.09		30.3	

Results are listed as "onsite streams" in table 4. Two nearby offsite streams are also sampled to provide a comparison. All concentrations are less than the standard for drinking water. The results from the water sampling program are presented in table 4.

Table 4. Water monitoring, LRL Berkeley site July–December 1970

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Surface water:					
Onsite streams					
Blackberry	26	0.30	1.2	3.27	14.3
Lower Strawberry	26	.33	8.5	7.37	29.3
Upper Strawberry	26	.14	1.6	2.95	9.3
Summary		0.26	8.5	4.53	29.3
Offsite streams:					
Claremont	26	.68	2.9	3.00	13.3
Wildcat	26	.16	1.7	2.19	5.0
Summary		0.42	2.9	2.60	13.3
Tap water	24	.005	.37	1.35	3.2

Neutron and gamma-ray fields are measured at each of the four perimeter stations as well as at several locations within the site. Background measurements are obtained from a leased building used as a low-level counting room in downtown Berkeley. This building is remote from the main LRL site and measurements are not influenced by accelerator operations.

At each station, gamma measurements are made by a recording G-M detector, standardized with a calibrated radium source. These instruments operate unattended and each can operate for 1 week on its internal battery should external power fail.

Several neutron detectors are employed at each station. The primary detector is a BF_3 gas proportional counter in a 2½ inch-thick paraffin-lined moderator. This detector is sensitive in the region from 0.1 to 20 MeV, where 75 percent of the biologically significant neutrons exist. A polyethylene-lined proton recoil neutron detector provides a measure of the energy flux density. The ratio of energy flux density to neutron flux density gives the average neutron energy which allows conversion of the data to dose in rems. Cobalt disks in moderators are maintained as long term integrating neutron monitors at many sites throughout the laboratory as well as at each perimeter station.

Cosmic ray intensity is continuously monitored by a meson detector with an effective angle of acceptance of 2.3 steradians (in the upward direction). This provides information on the background neutron levels contributed by cosmic rays.

At each station, total radiation levels are well below the standards set for the general public by the ICRP and National Council on Radiation Protection and Measurements (NCRP). Results are presented in table 5.

Table 5. Beta-gamma and fast neutron surveillance results, Berkeley site, July–December 1970

Station	Total beta-gamma exposure (mrem) (background subtracted)	Total fast neutron exposure[a] (mrem) (background subtracted)
A	11.9	54.5
B	16.0	28.4
C	Background	Background
D	3.0	22.5
Downtown Berkeley	[b]	[b]

[a] 2.45×10^7 n/cm² = 1 rem.
[b] Detector not in service.

Livermore site

The Livermore site of LRL (figure 2) is located in the Livermore Valley midway between the Pacific coast and the San Joaquin Valley in

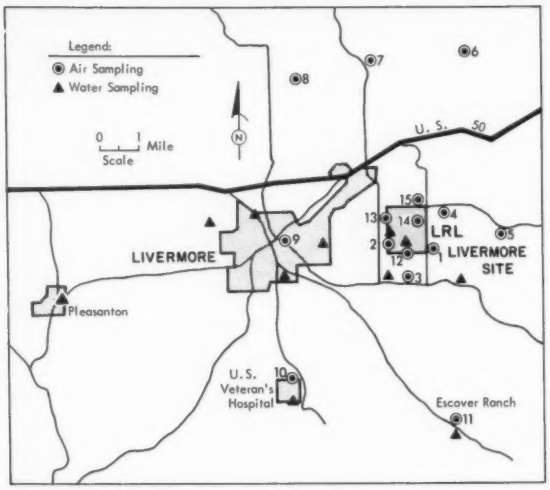

Figure 2. Environmental sampling locations at the Livermore site, Lawrence Radiation Laboratory

northern California, approximately 50 miles southeast of San Francisco. Shielded from the ocean by the western hills, the Livermore Valley has a warm, dry climate. Annual rainfall is about 14 inches with most of the precipitation occurring during the winter months. Prevailing winds are from the west, but inversions are frequent during the night.

Agriculture is the principal activity in the Livermore Valley. Roses, grain, hay, and grapes are the major products. Several cattle and sheep ranches surround the Livermore site.

The Livermore site comprises an area of 1-square mile, approximately 3 miles east of the city of Livermore. Livermore and Pleasanton, with a combined population of 45,000 are populated areas of primary interest to the Livermore site.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, sewage plant products, milk, and vegetation. The milk samples are obtained from one dairy in the Livermore Valley and from another dairy near Site 300.

Techniques

The LRL Environmental Program is currently undergoing a significant upgrading. This upgrading will greatly improve the analytical sensitivities in order to determine actual background levels of specific radionuclides in the environment. During the transition period, the program will consist of two parts, (1) the gross radioactivity measurements similar to those made in the past, and (2) the special measurements designed to measure the activity of specific radionuclides in environmental samples at background levels.

The analytical techniques used in the above measurements are provided below:

1. Gross radioactivity measurements:

An automated counting system is used for all environmental air samples. This system utilizes gas-flow proportional detectors for both alpha- and beta-particle counting. The alpha-particle detector is approximately 20 percent efficient for the 5.1 MeV alpha of plutonium-239. The efficiency for the 0.54 MeV and 2.27 MeV betas of strontium-90 in equilibrium with yttrium-90 is about 28 percent.

Soil, water, and sewage samples are counted on an automatic low-background system that detects alpha particles with an efficiency of about 34 percent at 5.1 MeV and strontium-yttrium-90 beta particles with an efficiency of approximately 50 percent.

The milk samples are concentrated using a vacuum-operated, foam-entrainment evaporator so that about 9 liters of whole milk are condensed to 2 liters by evaporation. The sample is counted in a plexiglass container placed between two 8- by 4-inch NaI(Tl) crystals. The data are recorded in a multichannel analyzer and processed by a computer code using standard spectra taken on the same counting apparatus.

The vegetation samples taken from nine locations throughout the Livermore Valley are dried in ambient air for about 1 week. Then 150–200 grams of dry material are pressed into a pellet 5 inches in diameter by ½ to 1 inch thick. The pellet is then counted on the system described for milk. The data are also processed by computer.

Samples of environmental water, milk, and vegetation are analyzed for tritium. One milliliter of water or distillate is counted in a liquid scintillation counter having a 32 percent efficiency for HTO.

The soil samples are prepared by digesting 1 gram of material in a mixture of perchloric and nitric acids and evaporating to near dryness. The

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resulting residue is redissolved in a hydrogen peroxide and nitric acid mixture and subsequently plated onto stainless-steel plates. The water and sewage samples, of ½ liter volume, are treated similarly.

2. Special measurements:

Soil samples are subjected to either a complete acid dissolution or the HASL[3] leach technique for plutonium-239 and strontium-90 determinations. A minimum of 100 grams of soil is used for these analyses. The cesium-137 activities in soil samples are determined directly by placing approximately 300 grams of soil on GeLi detector equipped with background and Compton suppression systems.

The water samples that are analyzed for tritium activity are pretreated by vacuum distillation under an argon atmosphere, enriched 75 fold electrolytically and counted by a liquid scintillation detector.

The air and water samples are subjected to gross alpha and gross beta measurements. Even though the analyses of these samples indicate that iodine-129, actinium-227, radium-226, and radium-228 are not present, the average gross alpha activities still may not exceed the AEC standards for air and water for controlled and uncontrolled areas. Since the alpha emitters have already been accounted for in the gross alpha measurements, the average gross beta radioactivity of the samples may not exceed the AEC standards for air and water for controlled and uncontrolled areas. The AEC Manual Chapter 0524 also states that the average tritium activities in offsite water samples may not exceed 3 μCi/liter.

The average monthly alpha and beta radioactivity of sewage effluent samples should not exceed the guide value of 400 pCi/liter (AEC standard for water in a controlled area), and the tritium activity should not exceed 10^3 pCi/liter.

The annual external radiation dose to the whole body of workers in controlled areas may not exceed 5 rem; while that to individuals in uncontrolled areas may not exceed 170 mrem.

Air and soil samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels that do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to ascertain that radioactivity is not entering the underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, the sole supply for ranches in the Livermore and Amador Valleys. Samples were taken at the Livermore Sewage Disposal Plant to establish that liquid effluent from the laboratory is not contributing significant radioactivity to the dried sludge or liquid effluent produced. The dried sludge is used as an agricultural soil conditioner. Some liquid effluent released to the Los Positas Arroyo is used for irrigation of the golf course turf and some agricultural land.

Air particulate samples were collected continuously at 15 sampling stations. The samplers situated on the laboratory perimeter utilize 80 square inch Whatman filters at an average flow rate of 25 cfm. The remaining samplers utilize 36 square inch HV-70 filters at an average flow of 4 cfm. Filters are changed weekly during the winter months and biweekly during the summer to avoid excessive mass loading. The results are shown in table 6.

At no time was any detectable alpha radioactivity observed on the air filters. The average airborne beta radioactivity was 0.1 pCi/m^3; about the same as that reported during the previous 6 months.

Soil samples were collected quarterly. Only the top 1 cm layer was collected at the 19 sampling locations in the Livermore Valley. The alpha radioactivity of each sample was less than the limit of detection (1.5 pCi/g). The beta radioactivities fluctuated from 4.7 pCi/g to 15 pCi/g with an average of 7.5 pCi/g. The limit of detection is 3.5 pCi/g. The radioactivity detected is within the normal range for soil in the Livermore Valley, as determined from surveillance during previous years.

Additional soil samples were collected onsite and offsite within a 4-square-mile area immediately east of the Livermore Laboratory. These samples were subjected to plutonium-239, strontium-90 or cesium-137 determinations. The first seven samples shown in table 7 were analyzed by complete acid dissolution of the soil while the remaining samples were subjected to the HASL acid leach technique

[3] HASL–Health and Safety Laboratory, U.S. Atomic Energy Commission.

Table 6. Airborne particulate radioactivity around LRL Livermore site July–December 1970

Sampling location	Number of samples	Alpha radioactivity[a] (fCi/m³)		Beta radioactivity[a] (fCi/m³)	
		Average	Maximum	Average	Maximum
1	46	≤0.4	≤0.4	107	210
2	49	≤ .4	≤ .4	98	230
3	26	≤1.0	≤1.0	72	144
4	24	≤1.0	≤1.0	85	204
5	25	≤1.0	≤1.0	87	191
6[b]	NS				
7	26	≤1.0	≤1.0	64	142
8	26	≤1.0	≤1.0	69	205
9	22	≤1.0	≤1.0	119	330
10	23	≤1.0	≤1.0	66	130
11	25	≤1.0	≤1.0	53	99
12	49	≤ .4	≤ .4	121	248
13	49	≤ .4	≤ .4	109	264
14	49	≤ .4	≤ .4	152	420
15	48	≤ .4	≤ .4	130	319
16	26	≤1.0	≤1.0	93	213

[a] Approximate limits of sensitivity: Alpha—locations 1, 2, 12–15—4 fCi/m³.
locations 3–11, 16—1.0 fCi/m³.
Beta—locations 1, 2, 12–15—4 fCi/m³.
locations 3–11, 16—10 fCi/m³.
Estimated counting error limits: alpha radioactivity ±30 percent; beta radioactivity ±20 percent.
[b] Sampler is being relocated.

Table 7. Radioactivity in soil samples, July–December 1970

Location	Depth (inches)	Average concentration (dpm/g)		
		Plutonium-239	Cesium-137	Strontium-90
Onsite[a]	0–2	$2.4\times10^{-2}\pm$ 5%	0.86 ± 6%	—
	2–4	$1.8\times10^{-2}\pm$ 6%	.69 ±13%	—
	4–6	$2.3\times10^{-3}\pm$13%	.20 ±25%	—
Offsite	0–2	$2.8\times10^{-3}\pm$16%	.38 ±21%	—
	2–4	$1.8\times10^{-2}\pm$26%	.44 ±25%	—
	4–6	$3.7\times10^{-4}\pm$20%	.15 ±53%	—
Offsite	0–2	$3.8\times10^{-3}\pm$19%	.22 ±36%	—
Offsite	0–6	$9.0\times10^{-4}\pm$ 9%	≤ .03	0.099±11%
	0–6	$1.2\times10^{-3}\pm$10%	≤ .03	.061±18%
	0–6	$3.9\times10^{-3}\pm$ 5%	.081±22%	.077± 7%
	0–6	$2.8\times10^{-3}\pm$ 6%	.063±27%	.082± 7%
	0–6	$2.5\times10^{-3}\pm$ 6%	.050±32%	.055±14%
	0–6	$8.6\times10^{-4}\pm$11%	≤ .03	.045±14%

[a] Adjacent to area used for solar evaporation of radioactive liquids.

for plutonium-239 determination. Each sample was collected over a 10 square-inch surface area.

Domestic water samples were collected monthly from 10 nearby sources. No sample showed an alpha radioactivity above the limit of detection (1.2 pCi/liter). The gross beta radioactivities are shown in table 8.

The limit of detection for gross beta radioactivity is 2.5 pCi/liter. The tritium activity of the water samples fluctuated from below the limit of detection (3.5 nCi/liter) to 5.4 nCi/liter. The average tritium activity was ≤3.6 nCi/liter. Several water samples were collected weekly

Table 8. Beta radioactivity in domestic water supplies LRL Livermore site, July–December 1970

Dosimeter location	Beta radioactivity[a] (pCi/liter)	
	Maximum	Average
1	3.4	3.4
3	7.7	2.8
4	5.9	≤2.5
5	4.1	≤2.5
6	3.2	≤2.5
7	14	4.1
8	5.5	≤2.5
10	4.5	≤2.5
Building 253	≤2.5	≤2.5
Building 419	≤2.5	≤2.5

[a] The limit of detection for gross beta radioactivity is 2.5 pCi/liter.

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during the months of July, August, and September from the city of Livermore and Site 300 wells, as well as other miscellaneous sources of drinking water in the immediate vicinity of the laboratory. The weekly samples collected at a particular source were composited into a single sample from that source. Tritium results are shown in table 9.

Table 9. Tritium radioactivity in water LRL Livermore, July–December 1970

Livermore		Site 300	
Well number	Tritium (pCi/liter)	Well number	Tritium (pCi/liter)
8	19±19	1	14±14
9	22±10	3	≤14
10	25±18	4	≤20
13	75±15	5	23±14
14	72±13	6	50±18
15	17±14	7	≤13
17	39±12	8	≤20
19	74±15		
20	80±17		

Samples were collected daily at the laboratory sewer discharge. A portion of each of these daily samples were composited during each month. These monthly composite samples for the radionuclides analyzed are shown in table 10.

When the sewage from the laboratory and city of Livermore enters the sewage disposal plant, the liquid and sludge are separated, and the sludge passes into one of two digesters where it is broken down by bacterial action. Methane gas is evolved and burned and the remaining sludge is released to large, sludge lagoons and/or drying beds and

Table 10. Radioactivity in laboratory sewer effluent samples July–December 1970

Month (1970)	Alpha radioactivity (pCi/liter)		Beta radioactivity (pCi/liter)		Tritium (nCi/liter)		Strontium-90 (pCi/liter)	Radium-226 (fCi/liter)	Radium-228 (pCi/liter)	Mixed iodine (pCi/liter)
	Maximum	Average	Maximum	Average	Maximum	Average				
July	24	8.0	1,040	157	500	22	5.1	34	0.36	0.34
August	18	4.0	1,724	387	68	6	22	120	1.1	3.8
September	9	≤1.2	213	102	21	4.6	4.9	45	.37	60
October	1.2	≤1.2	210	75	14	4.7	4.0	18	.35	25
November	19	4.0	285	105	24	7.5	7.4	150	1.7	11
December	19	7.0	373	77	82	25	4.5	35	.39	9.1

Table 11. Radioactivity in samples from the Livermore sewage disposal plant, July–December 1970

Radioactivity, units of measurement and location of sampling	1970					
	July	August	September	October	November	December
Gross alpha (pCi/liter)						
Digesters:						
Maximum	452	455	321	508	220	338
Average	306	290	254	276	144	214
Aeration tank:						
Maximum	201	120	150	33	41	86
Average	163	107	64	24	27	42
Effluent:						
Maximum	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2
Average	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2	≤1.2
Gross beta (pCi/liter)						
Digesters:						
Maximum	2,000	5,500	1,200	1,300	6,200	1,800
Average	1,300	1,700	830	800	500	750
Aeration tank:						
Maximum	325	329	417	84	70	103
Average	281	213	206	67	55	58
Effluent:						
Maximum	45	130	45	28	25	32
Average	28	46	19	13	8	13
Tritium (nCi/liter)						
Aeration tank:						
Maximum	4.0	5.0	≤3.5	≤3.5	≤3.5	33
Average	≤3.6	≤3.9	≤3.5	≤3.5	≤3.5	≤9.7
Effluent:						
Maximum	29	7.0	≤3.5	4.0	≤3.5	12
Average	≤6.6	≤3.9	≤3.5	≤3.5	≤3.5	≤5.8
Strontium-90 (pCi/liter)						
Effluent:						
Average	NA	NA	≤ .4	≤ .4	1.0	.5

NA, no analysis.

retained for subsequent possible use as a soil conditioner. The purified water is used on the Livermore golf course and agricultural irrigation on a nearby farm; the excess is discharged into the Los Positas Arroyo. Samples were collected weekly from the aeration tanks, each digester, and the effluent to the arroyo. The results of these analyses are given in table 11. The limits of detection are 1.2 pCi/liter for the gross alpha radioactivity, 2.5 pCi/liter for the gross beta measurements, 3.5 nCi/liter for the tritium determinations, and 0.4 pCi/liter for strontium-90.

Samples were collected monthly from each of two dairies in the Livermore Laboratory and Site 300 areas. The average radioactivity in the milk samples is shown in table 12.

Table 12. Radionuclides in milk, LRL July–December 1970

Location of dairy	Concentration (pCi/liter)		
	Cesium-137	Cerium-144	Tritium
3 miles north of Site 300	≤1.9	≤3.5	≤3,500
6 miles west of Livermore Laboratory	2.7	≤5.5	≤3,500

Samples of vegetation were collected during July and October of 1970; the radioactivity per unit dry weight of unwashed grass samples and eucalyptus leaf samples is shown in table 13. A portion of each sample was freeze dried and the water collected was analyzed for HTO.

Continuous air sampling is maintained on the stack effluent from operations that are potential sources of radioactive material releases. These facilities include hot cells, transuranic chemistry, plutonium metallurgy, and the reactor building. The effluent from these buildings passes through high-efficiency filters prior to being exhausted to the atmosphere. The offsite concentrations were not exceeded as a result of the stack effluent from these facilities.

The measurement of low-level gamma radiation was accomplished with thermoluminescent dosimeters at nine points on the site perimeter and at three offsite locations. The dose received by each detector during the 6-month period is shown in table 14. The limit of detection of these dosimeters is 10 mR.

Accidential release of tritium gas

Continuous air sampling is also maintained on the stack effluent from the gaseous chemistry Building. On August 6, 1970, an accidental release of tritium gas occurred from this facility. During the following 4 days, an extensive environmental sampling program was conducted to evaluate the effects of the release on the environment. The vast amount of environmental data that was obtained is too voluminous to report here and will be reported shortly in a separate publication.

The limits of detection for tritium is 5 nCi/liter of water and 40 pCi/m³ of air. The data indicate that no significant exposure to onsite or offsite individuals resulted from the release. Detectable activities were observed in some vegetation and atmospheric water vapor samples. However, even the highest measured concentrations, as well as the

Table 13. Radioactivity in vegetation, LRL Livermore site, July–December 1970

Nuclide	Concentration (pCi/g dry weight)				Limit of detection
	Grass		Eucalyptus leaves		
	Average	Maximum	Average	Maximum	
Beryllium-7	1.1	3.1	0.58	1.2	0.01
Manganese-54	.18	1.1	≤ .01	≤ .01	.01
Zirconium-95	.49	1.6	.16	.37	.01
Ruthenium-103	≤ .02	.04	≤ .02	.04	.02
Ruthenium-106	.56	2.7	.31	.96	.02
Antimony-125	≤ .02	.03	≤ .02	.09	.02
Cesium-137	.04	.12	.06	.13	.01
Barium-140	.52	1.9	.07	.11	.01
Cerium-144	1.5	4.1	.64	1.3	.02
Tritium (nCi/liter)	14	22	5.8	17	3.5

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Table 14. External gamma radiation measurements LRL Livermore site, July–December 1970

Dosimeter locations[a]	Exposure[b] (mR)
1	17
2	≤10
3	≤10
4	≤10
5	70
6	≤10
7	17
8	14
9	15
10	≤10
11	≤10
12	≤10

[a] Locations 1–9, controlled area perimeter. Locations 10, 11, and 12, uncontrolled area.
[b] Minus backgroud.

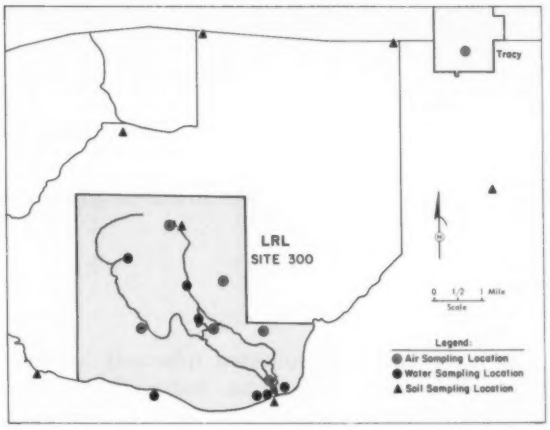

Figure 3. Sampling location at Site 300, LRL

calculated maximum credible ground level air concentration, that could have resulted during cloud passage were well below the offsite maximum permissible concentration for continuous exposure.

Site 300

The high explosive test area at Site 300 (figure 3) covers 10-square miles in the hills, in a very sparsely populated ranching area about 15 miles southeast of Livermore and 8 miles southwest of Tracy. The chief area of concern for Site 300 is Tracy with a population of about 15,000. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The 11 air samplers at Site 300 are operated on a continuous basis at about 25 cfm and the filter papers are changed weekly. Most of these air samplers are located within the boundaries of the test site due to unavailability of electric power facilities offsite. Table 15 gives the airborne particulate radioactivity for July–December 1970. Water samples are collected monthly from onsite wells. Streams in the area are sampled when they contain water (usually during the winter). No sample showed an alpha radioactivity concentration above the limit of detection (1.2 pCi/liter). The average beta concentrations are given in table 16. The tritium activities of the water samples fluctuated from below the limits of detection (3.5×10^3 pCi/liter) to a high of 8.6×10^3 pCi/liter. The average tritium activity was $\leq 3.8 \times 10^3$ pCi/liter.

Table 15. Airborne particulate radioactivity, LRL Site 300, July–December 1970

Sampling location	Number of samples	Alpha radioactivity[a] (fCi/m³)		Beta radioactivity[a] (fCi/m³)	
		Average	Maximum	Average	Maximum
1[b]	34	<0.2	0.2	161	378
2	31	< .2	1.0	210	418
3	35	< .2	1.0	181	472
4	30	< .2	< .2	192	386
5	34	< .2	6.6	136	304
6[b]	10	< .2	< .2	132	212
7	34	<1.0	<1.0	148	332
8	33	< .2	< .2	164	430
9	34	< .2	1.1	233	521
10	23	< .2	1.0	180	399
11	33	< .2	< .2	147	372
Summary	331	<0.2	6.6	171	521

[a] Limit of detection: alpha radioactivity, location 1–6, 8–11, 0.2 fCi/m³; location 7, 1.0 fCi/m³; beta radioactivity, location 1–6, 8–11, 2 fCi/m³; location 7, 10 fCi/m³.
Variations in limits of detection results from differing flow rates. Estimated counting error limits, alpha radioactivity ±30 percent; beta radioactivity ±20 percent.
[b] Sampler inoperative for several weeks.

Table 16. Beta radioactivity in water samples, LRL Site 300, July–December 1970

Sampling location	Beta radioactivity (pCi/liter)	
	Maximum	Average
1	3.6	2.6
2	6.8	4.7
3	9.5	6.9
4	8.6	4.9
5	10.9	5.7
6	6.4	3.4
7	6.8	5.2
11	10.9	7.9
14	7.7	6.2

Soil samples were collected quarterly at nine offsite locations. The alpha radioactivity was below the limit of detection (1.5 pCi/g). The beta radioactivity ranged from the limit of detection (3.5 pCi/g) to 15 pCi/g, with an average activity of 5.9 pCi/g.

None of the average concentrations of air, water, and soil samples exceeded the concentration guide levels of environmental radioactivity, nor did any of the results increase significantly compared to the previous 6-month reporting period. Therefore, it appears that radiological control measures at Site 300 were adequate and that no significant radioactivity was released to the environment near the site during this period.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1969	November 1970
January–June 1970	May 1971

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Reported Nuclear Detonations, September 1971

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals from a Soviet underground nuclear explosion in the range of 2 to 4 megatons were recorded by the United States. The signals originated at approximately 2:00 a.m., EDT, September 27, 1971, at the Novaya Zemlya nuclear test area in the Arctic.

The signals from this test were almost as large as those of the 3 to 6 megaton test conducted at Novaya Zemlya by the U.S.S.R. last year on October 14.

The U.S Atomic Energy Commission announced only one underground nuclear test for September 1971. This nuclear test was in the low yield range of less than 20 kilotons TNT equivalent. It was conducted on September 29, 1971, at the U.S. Atomic Energy Commission's Nevada Test Site in the Yucca basin, 1,240 feet below the desert floor.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U. S. nuclear detonations may be obtained upon request from the Division of Public Information, U. S. Atomic Energy Commission, Washington, D. C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

A JOINT X-RAY RADIATION SURVEY IN PUERTO RICO, 1968. *Michael Gileadi. Radiological Health Data and Reports, Vol. 12, October 1971,* pp. 495–499.

The objectives, scope, and methods used in the 1968 Joint Radiation Survey Project, sponsored jointly by the Puerto Rico Nuclear Center and by the Department of Health of the Commonwealth of Puerto Rico, are described. The most significant results concerning the western and southern regions of the Island are presented. Most of the three quantifiers (mean gonadal dose, per capita per annum gonadal dose, and genetically significant dose) were smaller in the southern region than those in the western region.

KEYWORDS: Puerto Rico, radiation, survey, x ray.

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